PATENT
0104-0354P

IN THE U.S. PATENT AND TRADEMARK OFFICE

Applicants:	William HOLM et al.	Conf.:	7653
Serial No.:	09/901,592	Art Unit:	1762
Filed:	July 11, 2001	Examiner:	Nguyen, Donghai D.
For:	METHOD AND APPARATUS FOR APPLYING VISCOUS MEDIUM ONTO A SUBSTRATE		

DECLARATION UNDER 37 C.F.R. §1.132

Assistant Commissioner for Patents
Washington, DC 20231

Sir:

I, Dr. William Holm, residing at Skalbaggestigen 14A, SE-125 51 Älvsjö, Sweden do declare and say as follows:

1. I am familiar with the subject matter of the above identified application (United States Serial No. 09/901,592) of which I am a contributing inventor.

2. In the Examiner's Office Action dated September 11, 2008, the Examiner rejects claims 1, 8, 19, 20, 31, 34, 39, and 43 under 35 U.S.C. § 102(b) as being anticipated by Todd et al, U.S. Patent No. 5,639,010. Furthermore, claims 1-8, 19, 20, 31, 34, and 37-44 are rejected under U.S.C. § 103(a) as being obvious when compared to Cutting et al, U.S. Patent No. 5,638,597, in view of JP Patent Publication Number 2-200,367 to Osamu. These rejections were upheld in the Advisory Action dated December 23, 2008. I do not agree with the Examiner's rejections for the following reasons.

3. The Todd et al reference discloses a method of dispensing adhesive to a circuit board screen printed with solder paste. The reason to apply the adhesive is to prevent movement of surface mount devices during the solder reflow process (see column 1 lines 12-25). The application of adhesive is described in column 3 lines 13-17: "In step 34, an adhesive is dispensed on the circuit board in the areas where a surface mount device will later be affixed. Typically a drop of adhesive is dispensed via automated equipment between two solder pads on the circuit board." The skilled person would, at the time of the invention interpret "dispensing" as being conventional contact dispensing. The examiner argues that use of the word "drop" implies that the adhesive is "dropped, 'non-contact dispensed' on the substrate". It is submitted that such an interpretation is not reasonable; Merriam-Webster's dictionary states that a drop is "the smallest practical unit of liquid measure". There are several examples in the SMT literature where the word "drop" is used to describe an amount of liquid contact dispensed onto a substrate although "dot" is more common; on page 671 in "Electronic Materials Handbook" [1] the words "drop" and "dot" are used as synonyms, on page 141-143 in "SMT Soldering Handbook" [2] the words "drop" and "dot" are used alternately. In view of this, it is my opinion that Todd et al. discloses contact dispensing and not non-contact dispensing as in the present invention.

4. The Cutting et al reference discloses a manufacturing method for flexible circuit board assemblies. This method comprises inter alia screen printing of solder paste, reflowing said solder paste to form solder joints and bumps, inspecting said joints and bumps, and adding extra solder if needed (column 4 line 48 – column 5 line 21). This is clearly not the same method as claimed in the present invention. First of all, the adding of extra solder is done to correct for random defects found after reflow. In the present invention, some solder paste is intentionally applied via screen printing and some intentionally applied via jetting.

The reason for doing this is to make up for inherent deficiencies of the screen printing process, see paragraph [0015] of the published application of the present invention. The word "predetermined" in the claims should be interpreted in light of the specification and from this it is clear that Cutting et al. describes something different (see paragraph [0030] of the published application).

The examiner seems to disregard the difference pointed out above but admits that Cutting et al fails to teach add-on jetting wherein the add-on jetting is non-contact dispensing. To make up for this deficiency the examiner cites Osamu as an example of non-contact dispensing. First of all, it should be noted that Osamu does not disclose adding of predetermined amounts of viscous medium. Osamu discloses an apparatus for correcting solder defects, wherein an automatic solder inspection apparatus identifies defects that are then corrected. Similar to the case of Cutting et al., extra solder is added to correct random defects and not as an intentional part of the production process. Furthermore, the examiner is of the opinion that Osamu discloses adding solder via non-contact dispensing. The skilled person would not make this interpretation. The text only uses the word "dispense" which is normally interpreted to mean conventional contact dispensing. In the Advisory Action of December 23, 2008 the examiner relies on Figure 5 in the Osamu reference, which shows a dot of solder paste on a circuit board and a dispenser above it. The skilled person would interpret this as the typical dot shape achieved with contact dispensing, where the dot is formed by letting the fluid wet the workpiece (as seen in Figure 4 in the Osamu reference) and then retracting the dispense tip. During the retraction phase part of the fluid follows the tip until it breaks off forming a characteristic apex (see Figure 1 below and [3]). This corresponds to the dot shape shown in Figure 5 of the Osamu reference. In the case of jetting the dot shape is markedly different as can be seen below in Figure 2.

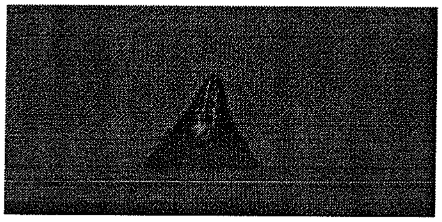


Figure 1 Microscope photograph of solder paste dot applied by contact dispensing (Copyright MYDATA automation AB 2009).

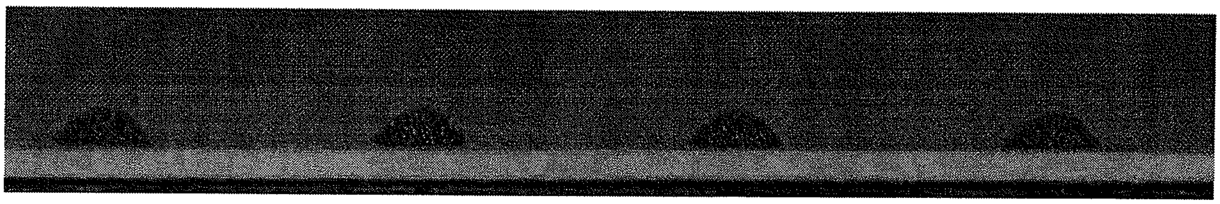


Figure 2 Microscope photograph of solder paste dots applied by jetting (Copyright MYDATA automation AB 2009).

5. In view of the above, it is my opinion that the Examiner's rejections of the claims are improper and should be reconsidered and withdrawn.

6. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

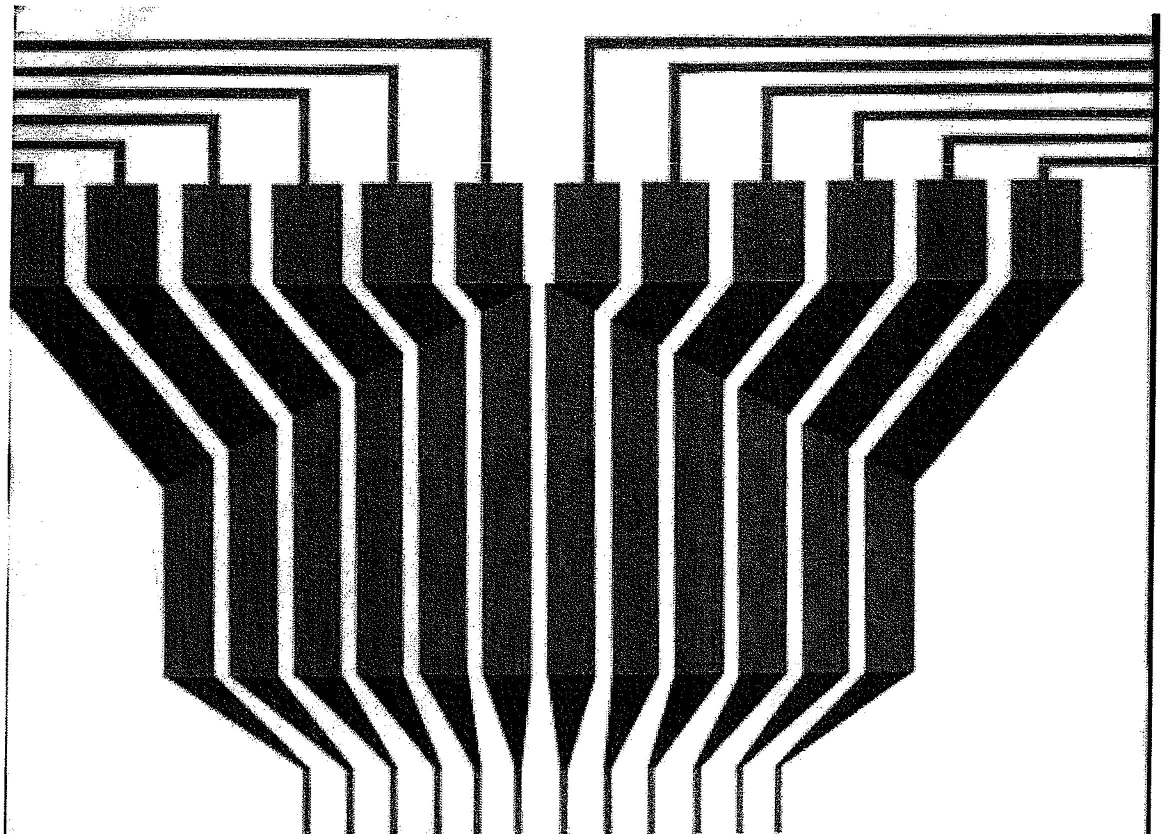
FEB 6, 2009
Date

By William Holm
Dr. William Holm

[1] Electronic Materials Handbook: Packaging, Volume I, p. 671
By Merrill L. Minges, ASM International Handbook Committee
Published by ASM International, 1989
ISBN 0871702851, 9780871702852
http://books.google.com/books?id=X3Ak_v4hFJYC&pg=PA671&dq=dot+drop

[2] SMT Soldering Handbook, pp. 141-143
By Rudolf Strauss
Published by Elsevier, 1998
ISBN 0750635894, 9780750635899
http://books.google.com/books?id=lN6-cBaeJcsC&pg=PA141&dq=dot+drop

[3] The Dawn of Micro-Dispensing
By Russ Peek
SMT Magazine , July 2001
http://www.gpd-global.com/pdf/Fine_Pitch.pdf



Electronic Materials Handbook™

Volume 1 Packaging

ASM INTERNATIONAL

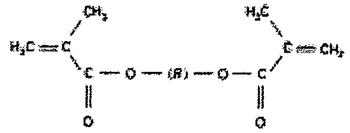


Fig. 2 Acrylic molecule, where [R] is a molecular chain selected for the best balance of properties

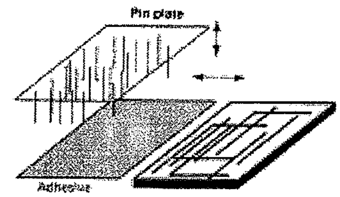


Fig. 3 Pin transfer method

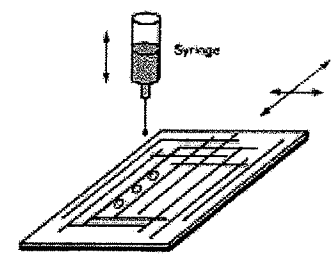


Fig. 4 Syringe dispenser method

because the cure allows maximum stability at room temperature for the critical processing properties of the adhesive. A typical curing schedule is 2 to 3 min at a bond line temperature of 120 °C (250 °F) or 1 to 2 min at 150 °C (300 °F).

Acrylic adhesives are based on dimethacrylate esters, of the general formula shown in Fig. 2. With acrylic adhesives, there is a much larger variety of chemical structures available to use as the central backbone of the resin molecule.

Acrylics are cured by a free-radical initiated addition reaction in which a small amount of free radical initiator causes cross-linking among the double bonds in the methacrylate end groups. Typical heat cure cycles are 2 to 3 min at 120 °C (250 °F) or 30 to 40 s at 150 °C (300 °F).

Acrylic adhesives may also be cured by ultraviolet (UV) energy. This is accomplished by using a second initiator that is sensitive to the UV light. Extremely rapid curing of that portion of the adhesive exposed to the UV light then occurs.

Acrylic adhesives are usually stable, single-component materials that are easier to process than are epoxies. However, areas of adhesive exposed to air are hard to heat cure because of the free-radical inhibiting influence of oxygen (Ref 2). This represents a limitation of the acrylics.

In practice, both the epoxy and acrylic chemistries find wide use. As long as the process is set up to handle one or the other, either type of product will perform well for most applications. Care should always be exercised when changing from one adhesive to another in an application, particularly if the basic product chemistry of the second adhesive is different.

SMT Adhesive Classification

Because SMT adhesives are still a developing technology, the system for classifying them is also evolving and is therefore not universally recognized. However, it is clear that, at a minimum, the following categories will be required.

Classification by Function. There are currently only two functional categories: general-purpose adhesives, which are intended for component positioning only, and thermal conductive adhesives, which help remove heat from the component. However, there has been some interest in other functions, such as electrical conductivity.

Classification by Machine Type. To achieve maximum productivity from the SMT assembly process, it is necessary to adjust the working properties of the adhesive to match the application method. Because the three major application methods are pin transfer, syringe dispense, and screening, at least that many classes of adhesive are needed. In addition, because machines from different suppliers are unique in design, it is not uncommon to have an adhesive specifically formulated for a given brand and model of machine.

Classification by Cure System. The most popular cure systems are heat (infrared or convection), UV light, or combinations of the two. However, other products based on moisture cure or two-component room-temperature cure have been tested and used to some extent.

Classification by Quality. The distinction in this classification depends on whether or not the user is concerned with the long-term properties of the adhesive as a component of the PWB. If the user's need is solely to position the component prior to soldering, as was predominantly the situation in the early days of SMT adhesive use, it is possible to focus only on working properties and short-term adhesive strength. Recently, however, there has been increasing concern over the behavior of the adhesive as a long-term component of the PWB. To address these concerns, it is necessary to provide a higher level of testing, quality assurance, and documentation. As a result, two classes of material are evolving, one for general-purpose use and one that is more rigidly controlled for use in high-reliability applications.

Application Technology

Pin transfer is the preferred method of adhesive application for high production rates. In this process, a grid array of pins matching the pattern required on the PWB is used to apply the adhesive (Fig. 3). The pins are dipped into a reservoir of adhesive and brought into contact with the board surface. Drop (or dot) size can be changed by changing the diameter of the pins. A new template assembly is required for each circuit type. Equipment of this type is capable of production rates in the hundreds of thousands of placements per hour.

Adhesives for pin transfer application machinery must have a variable viscosity so that the pins can be rapidly and completely wetted, while still leaving a high dot height on the board. In addition, the adhesive must not cause stringing when the pins are withdrawn from the surface of the board, but should give a high green, or wet, strength to the part on the board. These diverse requirements result in a pin transfer adhesive that is thin when being moved, but thick when standing still on the board. This is known as thixotropy. The product should also have sufficient working life in the machine to avoid frequent cleaning of the pin assembly.

The precise shape of the adhesive dot depends on the size of the pin, the shape of the ends of the pin, and the properties of the adhesive. The adhesive must be formulated to maintain the dot profile over a reasonable period of time so that when the component is placed, it will contact the dot in the required location. It is particularly important that the dot maintain a minimum height above the solder pads so that contact is made with leadless devices or leaded components that may be raised slightly from the surface of the board.

Syringe dispense driven by air pressure is the most common method for lower production rate requirements. This system can be used for rates into the tens of thousands per hour.

In this system, the adhesive is dispensed from a nozzle that is moved over the surface of the board by a microprocessor-controlled *xy*-traversal mechanism (Fig. 4). At the correct location, the nozzle is lowered to the board surface, a pulse of air forces a dot of adhesive from the nozzle tip, and the syringe is withdrawn.

Syringe dispense requires that when the syringes are packed, they be completely free from air bubbles. Because the quantity of material dispensed per shot is in the range of 1 μL (35×10^{-6} oz), even the smallest bubbles cause missed shots, which in turn lead to missing components. In

SMT Soldering Handbook

4.8 The role of adhesives in wavesoldering

SMDs must be anchored to the board before they are wavesoldered because they have no leadwires or legs with which to hang on to the substrate. Adhesive joints have been found to provide the best answer to the problem. Their mechanical properties are adequate for the task, and they can be broken without undue force if necessary.

4.8.1 Demands on the adhesive and the glued joint

The glued joint must be strong enough to hold the component securely to the board during any handling operation which may precede the soldering process, for example the insertion of wired components with a 'mixed' board, and above all during the wavesoldering procedure itself. These mechanical loads are only modest, at most of a magnitude of a few newtons. It is important, however, that the joint does not distort or disintegrate under the influence of the flux solvents during the preheating stage, and especially during the passage through one or two solderwaves.

Should the removal of a glued and soldered component become necessary because on inspection it has been found to be faulty or wrongly placed (Section 10.2), the joint should be capable of being broken without undue force and consequent damage to the substrate (Section 4.8.5). Finally, during the life of the assembly, the glued joints should not give off or leak any substance, particularly not one of an ionic nature, which could lower the surface resistance of the board or interfere with the function of the assembly.

4.8.2 Storage and handling behaviour of adhesives

Adhesives for SMDs are of the reactive, single-component epoxy or acrylic type. Solvent-containing adhesives and two-component reactive adhesives, which require mixing before use, are unsuitable for industrial SMD wavesoldering.

Single-component adhesives are a mixture of two ingredients, a polymer-resin and a hardener, which are capable of reacting with one another, forming a rigid structure of crosslinked molecules. This reaction requires a trigger to set it off, which may be a rise in temperature, or exposure to light in the visible or the UV range, or both these triggering agents, acting simultaneously or in sequence.

A good SMD adhesive must satisfy a number of specific requirements:

1. During storage, resin and hardener should not of course react with one another. With some adhesives, this may require storage in a refrigerator at about 5 °C/40 °F, to ensure a storage life of up to one year, which is what the industrial user expects. With many modern adhesives, refrigeration is no longer necessary, and storage times of up to one year at room temperature (say 25 °C/78 °F) are not unusual.
2. A drop of adhesive, as dispensed onto the board, may have to bridge a gap between 0.01 mm/0.4 mil and 0.3 mm/12 mil in height (the standoff height of the component) while, depending on the geometry of the layout, its base may have to

fit into a very narrow gap between two footprints (about 1 mm/40 mil with a micromelf) (Figure 4.33). As a general rule, the dot as put down on the board should be about 0.05 mm/2 mil higher than the standoff height of the component which it has to hold down. This requires the dispensed adhesive to retain its shape without sagging or 'slumping'. Any sideways spread of the dispensed drop would not only lower its height, so that it might fail to contact and hold the component, but it could also spread over the adjacent solderpads, totally and possibly irreparably ruining their solderability, and thus the whole circuit board. The type of behaviour in which semiliquid substance retains its shape is called 'thixotropy'. For similar reasons, the solder pastes which are used in reflowsoldering must also exhibit thixotropy, which is discussed fully in Section 5.2.1.

Apart from a sideways slump of the adhesive drop, it would be equally fatal should one of the more mobile constituents of the adhesive leak out sideways from the drop and contaminate an adjacent solderpad. Finally, the adhesive must separate neatly from the dispensing nozzle or placement pin, without forming a tail or thread which might tip over and fall on a solderpad.

The flow behaviour of an adhesive is necessarily temperature dependent, making it more mobile at higher temperatures. Most manufacturers have succeeded in reducing this temperature dependence to a minimum. However, since a very precise dosage of the dispensed adhesive drop is of the essence, especially with very small melfs and chips, the dispensing ampoules on some placement systems are heated to a standard temperature.

As a rule, the adhesive does not sit directly on the FR4 of the board, but on the solder resist. This places certain demands on the adhesion and the surface properties of the latter which are discussed in Section 6.1.

Very often one or more conductors will pass between the solder pads of a

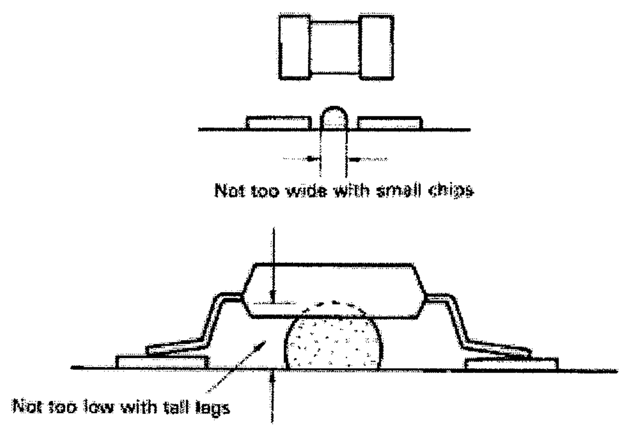


Figure 4.33 *Demands on the adhesive spot*

component. It is important that these conductor tracks are not covered with a layer of solder, as might be the case with boards made by a 'subtractive' process. If they are, the solder will melt underneath the solder resist as the board passes through the solderwave. Because the solder resist starts to crinkle as the solder on which it sits melts, the result is called the 'orange peel effect'. An SMD glued to the solder resist loses its safe anchorage when the solder underneath the resist melts, so that it is in danger of being washed off in the wave. For this reason, boards for wavesoldering SMDs should preferably be of the 'solder mask over bare copper' or 'SMOBC' type (see Section 6.1).

3. After an SMD has been placed on its adhesive dot, it must stick to it strongly enough to prevent it from shifting its position or falling off, while the board is handled between the placement of the components and the curing of the glued joints. This holding power of the uncured adhesive is called 'green strength'. Furthermore, an adhesive must be able to maintain its thixotropic behaviour and its green strength for at least 24 hours between being taken from its container, or discharged from its dispenser, and its being hardened or cured prior to soldering (open time).
4. Last, but not least, the adhesive should have a distinctive and conspicuous, perhaps luminous, colour, so that missing or misplaced dots are easily spotted. Orange or bright red seem to be the preferred shades.

4.8.3 Applying the adhesive

The precision of both the placement coordinates and the size of every individual dot of adhesive are critically important, especially with small melfs and chips: a misplaced dot, or one which is too large and becomes squeezed out during placement, is liable to cover a solderpad and make it unsolderable. Removing cured adhesive from a pad surface is one of the most costly and hazardous operations in corrective soldering (Section 10.1.1). On the other hand, a dot of insufficient height may not connect with the component it is supposed to hold.

In most situations adhesive dots have to be of varying height, for reasons explained above. There are several alternative methods to achieve this:

Sequential application of single dots

Dispensing the adhesives from the nozzle of a cartridge or ampoule is widely practised. Most vendors offer adhesives in air-pressure operated ampoules, which can discharge the content in a controllable manner. For manual placement, the pressure impulse in the hand-held ampoule is controlled by the operator through a footpedal or a press-button. The operation is simple, and misplaced adhesive can be wiped off, with solvents supplied by most vendors.

Dispensing adhesive from ampoules can be mechanized in two ways:

1. For putting down dots of adhesive onto boards before the components are placed, automatic equipment, which is capable of being programmed, is on the market. With these machines, the dispensing ampoule is mounted on an *xy*

The Dawn of Micro-Dispensing

Micro-dispensing handles small-dot solder deposition when stencil printing can't.

By Russell Peek

Featured as the cover story of the July 2001 issue of SMT magazine.

As the technology for small electronic products evolves, the printed circuit boards in these products become more densely populated, and with ever smaller components. While designers struggle to squeeze more components onto shrinking amounts of real estate, assemblers face the daunting task of depositing precise, tiny dots of solder paste. Measuring 10 mils or less in diameter, solder paste dots must attach components and complete electrical connections without creating shorts or bridges (Figure 1).

Stencil printing is the fastest way to deposit large volumes of solder paste, but when PCBs are densely packed, this approach becomes less practical. For the toughest applications, manufacturers turn to "micro-dispensing" equipment.

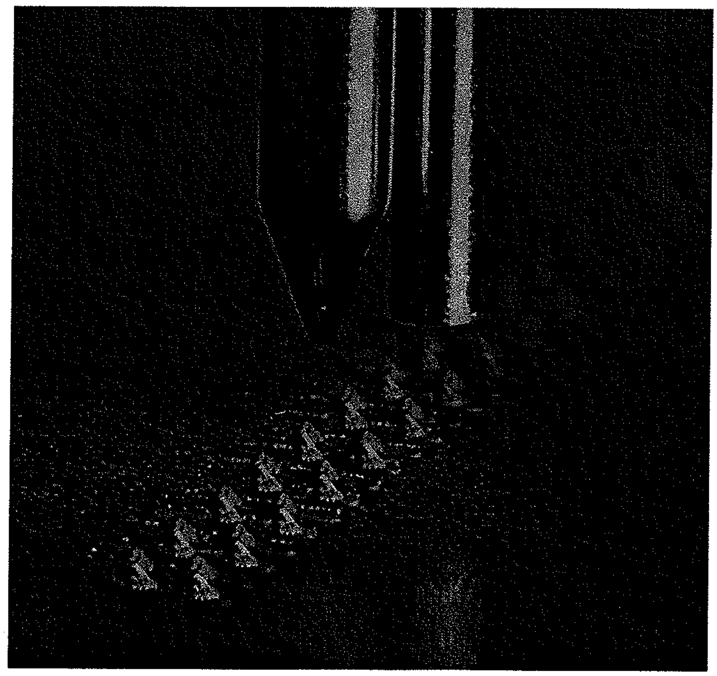


Figure 1. Because of the distance from pad to pad, fine-pitch solder paste dots must be dispensed in an offset pattern to avoid bridging during reflow.

Accurate, repeatable micro-dispensing depends on a variety of factors — from the air pressure at the inlet to the shape of the dispenser tip. Designed with these factors in mind, state-of-the-art micro-dispensing systems feature an array of hardware and software components that work together to put exactly the right amount of solder paste in exactly the right locations.

Material Considerations

A key to any micro-dispensing process is the composition of the solder paste. Important material considerations include the mesh size and metal content, plus how the material is packaged. These have a direct bearing on how the material functions during the dispensing process and ultimately, the quality of the interconnect.

For optimal dispensing, manufacturers should use a Grade 4 or 5 solder paste with 84-86 percent metal content. This is lower than the metal content of stencil printing pastes (normally 90 percent or higher). With lower metal content, the material flows better as it's dispensed.

Picking a Pump

Until recently, most micro-dispensing systems relied on time/pressure pumps. In these pumps, pulsing high-pressure air actuates a plunger that pushes material through a syringe. In the process, however, the pulsing air heats the material, changing both the viscosity and the dispensing volume. At the same time, the high air pressure breaks down the paste by separating the flux from the solder particles.

In new micro-dispensing valves, the time/pressure pump is replaced by a fully programmable auger pump. A low-pressure air supply keeps solder paste flowing into the pump cartridge without heating the material or breaking it down.

Attached to the pump is a motor that drives an Archimedian screw in the pump cartridge. Some systems employ DC motors that provide less-than-precise control of auger rotation. The reason: DC motors "ramp up" at the beginning of the dispensing process and "ramp down" at the end. These speed changes reduce the consistency of dispensed volume from one cycle to the next.

In more advanced systems, the DC motor is replaced by a brushless servo motor that provides constant speed. Attached to the motor is an encoder that precisely controls auger rotation. By breaking each turn of the auger into 57,000 segments, the encoder provides highly accurate dispensing.

Systems must also have software controlled auger speed to produce a repeatable dispense pattern. With finer mesh size and a large needle diameter, the pump speed can be increased. As the needle size is reduced, the pump speed must also be reduced. For example, pump speed of 250 rpm's is acceptable with a 20g needle and grade 4 material, whereas a 25-27g needle with grade 4 material must not exceed 45 rpm's.

As the auger screw wears down, dispensing volume changes — and accuracy and repeatability are lost. To minimize wear, both the auger and the cartridge liner are made of carbide steel. This carbide-in-carbide arrangement results in almost frictionless

pumping of the solder paste. Having a tight tolerance of 0.0002" or less between the auger and cartridge is also very important for high accuracy dispensing. This tight tolerance will reduce any type of material clogging caused by trapped material particles.

Needle Tips

Micro-dispensing requires a special tip, or needle, on the valve. As the pump screw turns, it pushes the solder paste out of the cartridge and into the needle, which deposits the material onto the printed circuit board (Figure 2).

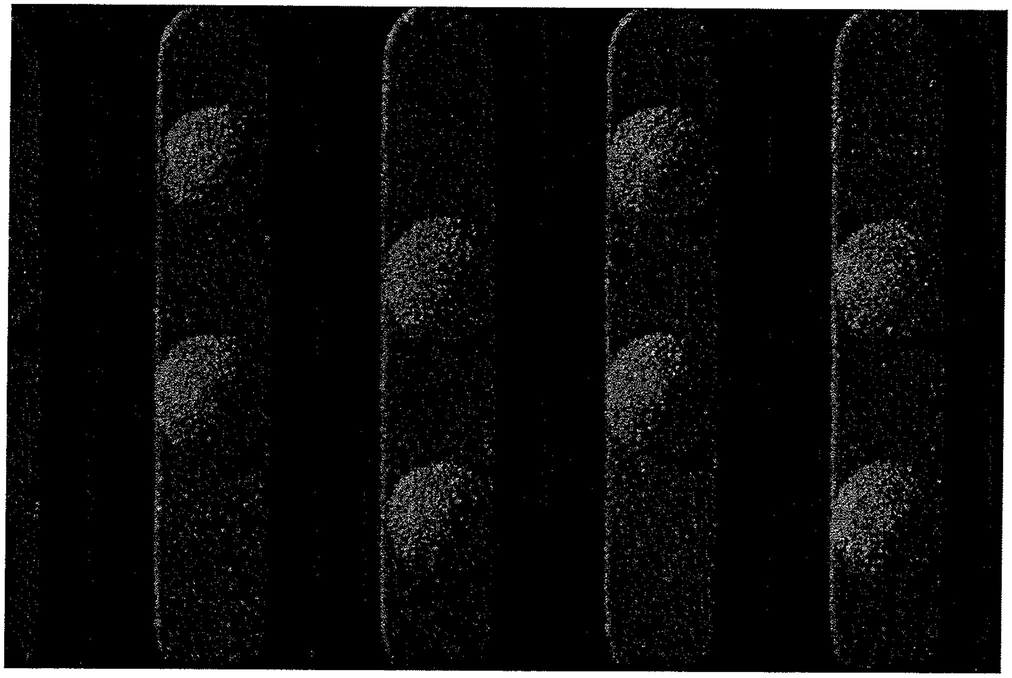


Figure 2. A footed needle is necessary to provide the correct Z-offset from the substrate and ensure the correct dot profile.

Most dispensing tips are made from rolled tubing. Often, though, this tubing has a poor interior surface that impedes material flow. This can result in clogging, a major problem in small-dot dispensing operations.

A better alternative is a stainless steel needle fabricated within tight tolerances. Needles that are precision machined from a single piece of solid stainless steel are ideal. A polished interior surface creates only minimal interference as solder paste moves over it, improving material flow and reducing the chances of clogging.

To reduce interior pressure, the inside needle diameter varies, with the largest cross section at the inlet end and the smallest at the tip. The tip is conically chamfered in the direction of material flow (Figure 3). This reduces surface tension between the needle and material at the point of separation, making it less likely that solder paste will cling to the tip. This, in turn, reduces the likelihood of tailing or bridging as the needle moves away from the dispensed dot. To find the dot diameter a needle will deliver, multiply the inside diameter by 1.5.

During dispensing, proper needle tip height must be maintained (Figure 4). A needle tip too close to the substrate can cause tailing and bridging, as well as carryover to the next dot location. A needle tip too far above the substrate can cause slumping of the dispensed material or bridging to the next location.

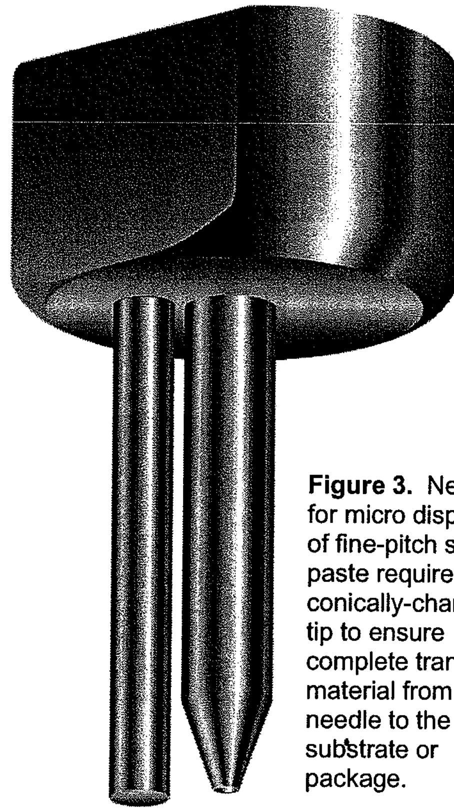


Figure 3. Needles for micro dispensing of fine-pitch solder paste require a conically-chamfered tip to ensure complete transfer of material from the needle to the substrate or package.

Needle tip height also determines the diameter-to-height ratio of the dispensed dot. For low-viscosity materials, the diameter-to-height ratio should be about 3:1; for high-viscosity pastes, the proper ratio is approximately 2:1. To determine the correct needle tip height, divide the inside diameter of the needle by two.

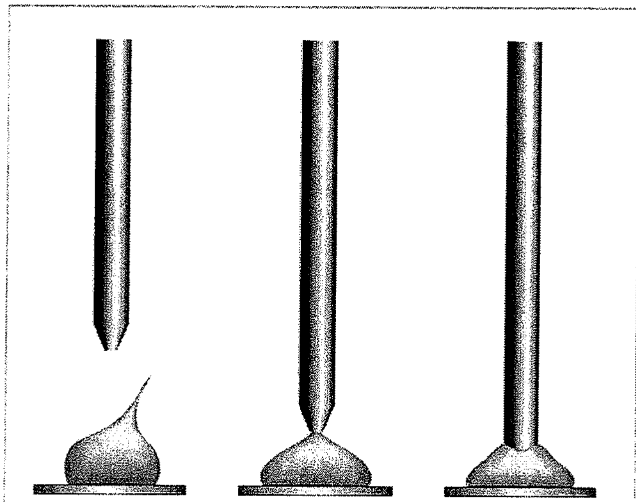


Figure 4. Needle tip height above the substrate determines the diameter-to-height ratio of the dispensed dot. A needle tip too far from the surface can cause slumping of the dispensed material. A needle tip too close to the surface can cause tailing and bridging of the material, as well as carry-over to the next dot location.

Platforms and Placement

While the pump assembly controls dot diameter and volume, the system's platform determines the accuracy of dot placement in X, Y, and Z directions. State-of-the-art platforms can achieve consistent positional accuracies within ±0.0015 inch and repeatability of ±0.0006 inch for all three axes.

Top-notch platforms include stainless steel components such as high-precision anti-backlash ball screws, linear bearing slides, and rails. They also include MIC-6 cast aluminum gantry plates, thereby ensuring additional X, Y locational accuracy.

The frame of these systems is made of a special composite material. Consisting of 90 percent quartz and 10 percent polymer, the material offers properties and weight that help the frame dampen shock and vibration caused by movement of the dispensing head.

Software Control

Essential to successful micro-dispensing is the software that controls deposition and gantry operations. Software compensates for deviations in motion and speed, ensuring precise, repeatable performance.

Advanced systems are managed by QNX, a Unix-like operating system developed specifically for precise machine control. QNX is a real-time multi-tasking software that provides process verification via closed-loop feedback within micro seconds. A Windows-type interface makes it easy for engineers to develop programs for a variety of applications.

Working within QNX is another software program, Contour Mapping®, that controls the gantry. This software maps each gantry position and automatically adjusts the system to correct inaccuracies in needle position.

Conclusion

As PCB space shrinks and component density soars, solder paste deposition gets too tough for conventional stencil-printing techniques. What's a manufacturer to do? Turn the process over to a micro-dispensing system. With hardware and software in control of every process variable, the system will accurately dispense the smallest dots in the tightest spots.

Contour Mapping® is a registered trademark of GPD Global.

RUSSELL PEEK, senior applications engineer, may be contacted at GPD Global, 2322 I-70 Frontage Rd., Grand Junction, CO 81505; (970) 245-0408; Fax: (970) 245-9647; E-mail: russ@gpd-global.com.